VIRGINIA TECH™

Updates to the Virginia Runoff Reduction Method

VT VRRM UPDATE TEAM

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Overview of Major Updates

1. Replaced the 'Simple' equation for water quality nutrient loading computations with loading rates established from CAST
2. Split the forest/open space category into two distinct VRRM categories, to result in four land cover types in VRRM 4.0.
3. Added in 2 new BMPs (Regenerative Stormwater Conveyance and Trees)
4. Updated the phosphorus target (old was 0.41 lbs/ac/yr) based land cover conversion data and CAST loading rates

DID NOT:

1. Modify treatment volume computation procedure (or 1" rainfall target)
2. Modify CNs or Rvs for existing VRRM categories

01

Existing VRRM Summary Information

VRRM 3.0 Converted Rates

- Simple Method equation was converted to loading rates for each VRRM category
- This step allowed VRRM 4.0 loading and nutrient tracking computations to be directly checked against the VRRM 3.0 spreadsheets
- Existing 'loading rates' calculated by entering 1 acre into each LC/HSG individually and recording the resulting computed TP

Current VRRM Loading Rates (lb/ac/year)

Category	*A*	*B*	*C*	*D*
Forest	0.046	0.068	0.091	0.114
Managed Turf	0.342	0.456	0.502	0.570
Impervious	2.167	2.167	2.167	2.167

Percentage of Total Loading Rates (per category)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

(43 in.)(0.90)(Rv/12)(0.26 mg/l)(2.72)

Current VRRM 3.0 Rvs

- Rv coefficients for each VRRM category as defined per VRRM documentation
- Derived from ranges established by a literature review
- Percentage rate (of each land use category total) are shown for later use in load assignment computations

Rv Coefficients

Category	*A*	*B*	*C*	*D*
Forest	0.020	0.030	0.040	0.050
Managed Turf	0.150	0.200	0.220	0.250
Impervious	0.950	0.950	0.950	0.950

Percentage of Total Rvs (per category)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

Current VRRM CNs

- Based on 3 land use covers with data from NRCS TR55 and NEH handbooks. Note that both publications show the same categories/values (currently)
- Current VRRM 3.0 'Managed Turf' category matches NRCS 'Open Space' and 'Pasture' CNs, for good condition

CNs

Category	*A*	*B*	*C*	*D*
Forest	30	55	70	77
Managed Turf	39	61	74	80
Impervious	98	98	98	98

Cover description: Cover type and hydrologic condition	Average percent impervious area 2/	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98

Sample from Table 2-2a, NRCS Technical Release 55, Urban Hydrology for Small Watersheds

02

Separation of VRRM Forest/Open Space

Basic Steps:

- Select candidate land cover types that capture elements of “Mixed Open” land use from NEH curve number tables
- Average the curve numbers reported across these land use types for each soil hydrologic group to generate CNs for “Mixed Open”
- Use the relationship between these CNs and existing CNs for managed turf and forest cover to establish weights that can be used to estimate Rv coefficients for mixed open from Rv coefficients from these other cover types

Recommendations from Internal Review VT/DEQ

Appropriate associated land covers were selected from the NEH curve number tables

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

Sample from Table 2-2c, NRCS Technical Release 55, Urban Hydrology for Small Watersheds

Recommendations from VT T...

Candidate matching land covers for 'Mixed Open' from TR-55 and NEH

Category	*A*	*B*	*C*	*D*
Meadow	30	58	71	78
Pastureland	39	61	74	80
Woods/Grass	32	58	72	79
Avg Mixed Open	**34**	**59**	**72**	**79**

Modified VRRM Table

CNs

Category	*A*	*B*	*C*	*D*
Forest	30	55	70	77
Mixed Open	34	59	72	79
Managed Turf	39	61	74	80
Impervious	98	98	98	98

Utility line easement, Appalachian Trail, Roanoke County, VA, C. Hodges, 8/28/22

*'***Mixed open***' is used to match the nomenclature of a similarly defined land cover in the CAST Model*

Rv Computation Procedure for Mixed Open Cover

CNs

Category	*A*	*B*	*C*	*D*
Forest	30	55	70	77
Mixed Open	34	59	72	79
Managed Turf	39	61	74	80
Impervious	98	98	98	98

Rv Coefficients

Category	*A*	*B*	*C*	*D*
Forest	0.02	0.03	0.04	0.05
Mixed Open	0.08	0.11	0.13	0.15
Managed Turf	0.15	0.20	0.22	0.25
Impervious	0.95	0.95	0.95	0.95

The relative placement of the Mixed Open cover CN between the 'forest' and 'managed turf' categories was used for weighting since the new category mixes characteristics of the other two.

Calculation procedure:

A soil: Rv = (.15-.02) / (39-30) x (34 – 30) + 0.02 = 0.08 (rounded up from 0.078)

B through D soils: Average of ratios of Rv rate increase to CN difference for Forest and Managed Turf (see next slide)

Rv Computation Procedure for Mixed Open Cover (cont.)

CNs

Category	*A*	*B*	*C*	*D*
Forest	30	55	70	77
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Impervious	98	98	98	98

Rv Coefficients

Category	*A*	*B*	*C*	*D*
Forest	0.02	0.03	0.04	0.05
Mixed Open	0.08	??	??	??
Managed Turf	0.15	0.20	0.22	0.25
Impervious	0.95	0.95	0.95	0.95

B through D soils: Average of ratios of Rv rate increase to CN increase for Forest and Managed Turf

Rv diff / CN diff = Incr.
(0.03-0.02)/25 = 0.0004
(0.25-0.22)/6 = 0.0050

CN Difference between adj. HSG

Category	*B-A*	*C-B*	*D-C*
Forest	25	15	7
Mixed Open	25	13	7
Managed Turf	22	13	6

Increment per CN interval

Category	*B-A*	*C-B*	*D-C*
Forest	0.0004	0.0007	0.0014
Mixed Open	0.0013	0.0011	0.0032
Managed Turf	0.0023	0.0015	0.0050

Average of Forest/MT
(0.0014+0.0050)/2 = 0.0032

Final Computed Rv Coefficients

Mixed Open	0.08	0.11	0.13	0.15

Calculation Examples:
B Soils: 0.08+25 x 0.0013 = 0.11
D Soils: 0.13+7 x 0.0032 = 0.15

VRRM 4.0 Proposed CN and Rv Summary of Key Constants

CNs

Category	*A*	*B*	*C*	*D*
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Rv Coefficients

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03

Assignment of Applicable CAST Land Covers

Basic Steps:

- Review CAST land covers
- Narrow the pool to only consider land covers that might correspond to general post-development VRRM land covers
- Omit land covers where load information is not available as well as covers like water or shoreline where the covers that contribute cannot be determined
- Assign remaining covers to VRRM land use classes based on the definitions reported in CAST

CAST Land Covers

- 49 total land covers
- Many are related to agriculture, treatment infrastructure, or other categories that do not suitably represent general post-development VRRM land covers
- Some applicable categories (primarily CSS) have suitable covers, but currently show no produced load in the CAST model

Natural
CSS Forest
CSS Mixed Open
Harvested Forest
Headwater or Isolated Wetland
Mixed Open
Non-tidal Floodplain Wetland
Shoreline
Stream Bed and Bank
True Forest
Water

Septic/Wastewater
Rapid Infiltration Basin
Septic
Combined Sewer Overflow
Industrial Wastewater Treatment Plant
Municipal Wastewater Treatment Plant

Developed
CSS Buildings and Other
CSS Construction
CSS Roads
CSS Tree Canopy over Impervious
CSS Tree Canopy over Turf Grass
CSS Turf Grass
MS4 Buildings and Other
MS4 Roads
MS4 Tree Canopy over Impervious
MS4 Tree Canopy over Turf Grass
MS4 Turf Grass
Non-Regulated Buildings and Other
Non-Regulated Roads
Non-Regulated Tree Canopy over Impervious
Non-Regulated Tree Canopy over Turf Grass
Non-Regulated Turf Grass
Regulated Construction

Agriculture
Ag Open Space
Double Cropped Land
Full Season Soybeans
Grain with Manure
Grain without Manure
Leguminous Hay
Non-Permitted Feeding Space
Other Agronomic Crops
Other Hay
Pasture
Permitted Feeding Space
Riparian Pasture Deposition
Silage with Manure
Silage without Manure
Small Grains and Grains
Specialty Crop High
Specialty Crop Low

Selected Land Covers

Developed

- ~~CSS Buildings and Other~~
- ~~CSS Construction~~
- ~~CSS Roads~~
- ~~CSS Tree Canopy over Impervious~~
- ~~CSS Tree Canopy over Turf Grass~~
- ~~CSS Turf Grass~~
- MS4 Buildings and Other
- MS4 Roads
- MS4 Tree Canopy over Impervious
- MS4 Tree Canopy over Turf Grass
- MS4 Turf Grass
- Non-Regulated Buildings and Other
- Non-Regulated Roads
- Non-Regulated Tree Canopy over Impervious
- Non-Regulated Tree Canopy over Turf Grass
- Non-Regulated Turf Grass
- ~~Regulated Construction~~

No loads were reported in CAST runs for CSS categories, so not currently used for loading rate computations

14 Total Land Covers Used

Natural

- ~~CSS Forest~~
- ~~CSS Mixed Open~~
- ~~Harvested Forest~~
- Headwater or Isolated Wetland
- Mixed Open
- Non-tidal Floodplain Wetland
- ~~Shoreline~~
- ~~Stream Bed and Bank~~
- True Forest
- ~~Water~~

No feasible way to break down into component covers

Assignment of CAST Land Covers to VRRM

Forest	Headwater or Isolated Wetland Non-tidal Floodplain Wetland True Forest
Impervious	MS4 Buildings and Other MS4 Roads MS4 Tree Canopy over Impervious Non-Regulated Buildings and Other Non-Regulated Roads Non-Regulated Tree Canopy over Impervious
Mixed Open	Mixed Open
Turf	MS4 Tree Canopy over Turf Grass MS4 Turf Grass Non-Regulated Tree Canopy over Turf Grass Non-Regulated Turf Grass

- Assignments are logically based on CAST terminology
- Assignments of 'Canopy over…' were assigned based on underlying cover due to winter foliage conditions
- 'Mixed Open' definition matches intent of the new VRRM mixed open category

04

Establish Nutrient Loading Rates

Determination of Loading Rates from CAST

Develop easy to use (and update) methodology to establish loading rates from CAST output

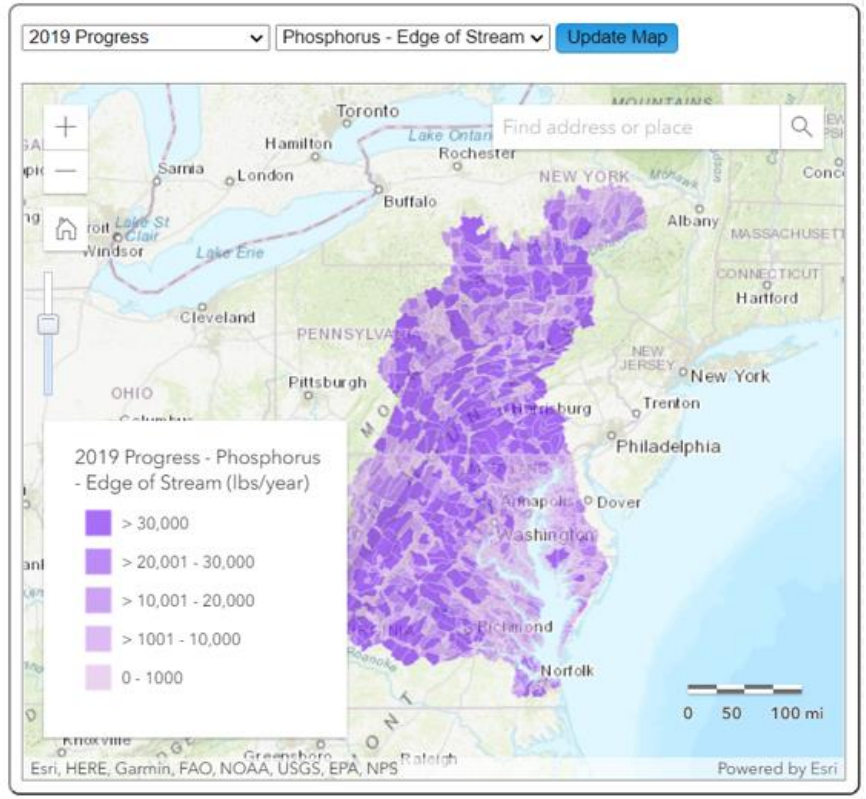
Steps to Accomplish this Goal:

- Review and aggregate the appropriate outputs of CAST Scenario Runs into the four VRRM land cover groups
- Compute the average loading rate for each
- Compute the breakdown of hydrologic soil classifications across the Chesapeake Bay portion of the Commonwealth
- Distribute the average loading rate between soil classifications using area breakdowns and Rv coefficient data
- Review output against VRRM 3.0 and address major issues

CAST Model Assumptions Regarding Loading Rates

- CAST model scenarios were run for the portion of the Commonwealth flowing to the Chesapeake Bay under a 'No BMP' implementation scenario since the VRRM spreadsheet should establish loading rates from data that is 'pre-treatment'

- Values from edge of stream (EOS) were used instead of edge of tide (EOT) since the most upstream values available would more realistically predict loads closer to a site before partial downstream load mitigation takes place.



Compute Average Loading Rate (sample for Managed Turf)

1. Compute area weighted consolidated CAST loading rates for each land use category:

	CAST Land Cover	Acres	EOS Load	Cast Loading Rate
Turf	MS4 Tree Canopy over Turf Grass	111,777	123,042	1.101
	MS4 Turf Grass	198,984	288,275	1.449
	Non-Regulated Tree Canopy over Turf Grass	217,436	253,570	1.166
	Non-Regulated Turf Grass	659,512	1,049,466	1.591
	Totals	**1,187,709**	**1,714,352**	**1.443**

1.443 Value is the average across all HSG soil groups

a. The area and loads for each land use category is summed.
b. The average land cover loading rate is computed by dividing the total EOS Load by the Total Acres.
c. Result is an overall average CB watershed loading rate in lbs/acres/year

Distribute the average loading rate across soil classifications (sample for Managed Turf,

	CAST Land Cover	Acres	EOS Load	Cast Loading Rate
Turf	MS4 Tree Canopy over Turf Grass	111,777	123,042	1.101
	MS4 Turf Grass	198,984	288,275	1.449
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	Non-Regulated Turf Grass	659,512	1,049,466	1.591
	Totals	**1,187,709**	**1,714,352**	**1.443**

2. It is assumed that loading rates will increase with increasing HSG classification, A → D, due to infiltrative capacity differences) loading rates due to averaging across all soils types. This means that:
   a) A type soil loading rates for Turf would be expected to be **less than** 1.443 lbs/ac/yr and conversely D soil rates would be expected to be **higher than** 1.443 lbs/ac year
   b) A methodology is necessary to proportion according to **both** the percentage breakdowns of A -> D soils in the Commonwealth and the relative infiltrative capacities of each

Assumptions necessary to solve for loading rates (HSG areas)

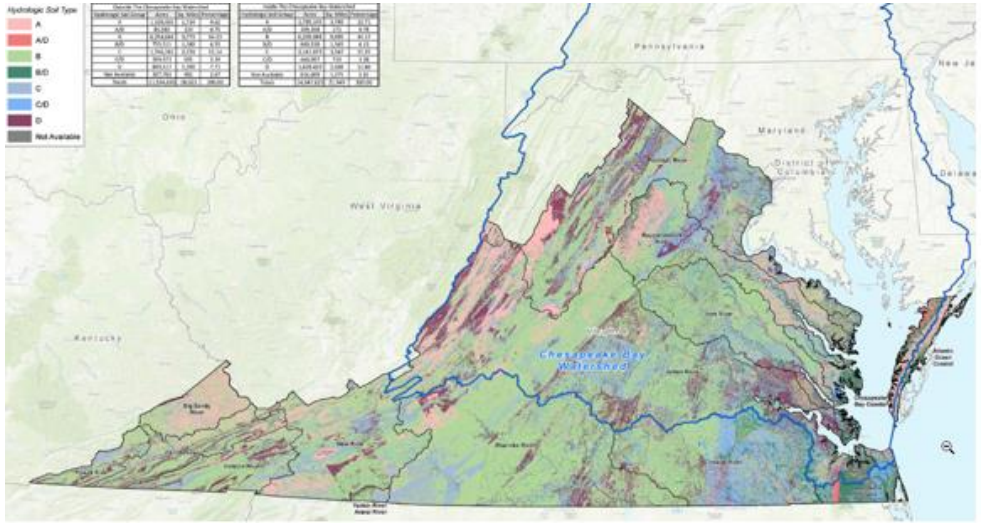
- An assumption regarding the average breakdowns of HSG soils contributing to each total weighted land cover loading rate must be made

- Percentages of HSG soils in the Virginia portion of the Chesapeake Bay watershed were used to fulfill this assumption

- A 50-50 split was assumed for soils with dual classification

Areas for Chesapeake Bay Watershed

HSG	Acres	Adjusted	Percentage
A	1,785,145.00	1,839,829.00	14%
A/D	109,368.00		
B	6,205,088.00	6,635,353.00	50%
B/D	860,530.00		
C	2,141,879.00	2,371,927.50	18%
C/D	460,097.00		
D	1,669,429.00	2,384,426.50	18%
Totals	**13,231,536.00**	**13,231,536.00**	**100%**



Assumptions necessary to solve for loading rates (runoff capacity)

- The VRRM Rv component percentages give an approximation of relative runoff capacity and are integrated in development of loading rate values

Current VRRM Spreadsheet Values

Percentage of Total Loading Rates (per category)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

Percentage of Total Rvs (per category)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

Proposed VRRM Spreadsheet Values

Loading Percentage Assignments (Matches Rv % Breakdown)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Mixed Open	17%	24%	27%	32%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

Used Microsoft Excel Equation Solver *(What-if goal seek)*

- Assume that the sum of the adjusted rates (sum of row) is 1.0*
- Create a formula in each cell that multiplies the 'Sum Adj. Rate' column by the appropriate percentage from the Rv table.

2021 Adjusted Loading Rates (lb/ac/year) - Phosphorus

Category	*A*	*B*	*C*	*D*	*Adj. Rate*
Forest	0.143	0.214	0.286	0.357	1.000
Mixed Open	0.168	0.240	0.271	0.320	1.000
Managed Turf	0.183	0.244	0.268	0.305	1.000
Impervious	0.250	0.250	0.250	0.250	1.000

Loading Percentage Assignments (Matches Rv % Breakdown)

Category	*A*	*B*	*C*	*D*
Forest	14%	21%	29%	36%
Mixed Open	17%	24%	27%	32%
Managed Turf	18%	24%	27%	30%
Impervious	25%	25%	25%	25%

**Note*: *Impervious analysis is not technically necessary since soil classification has no bearing on runoff capacity values, so distribution of loading rate will be even*

Use Microsoft Excel Equation Solver (What-if goal seek)

- Create another table with the following format

Adjustment Calculation for Loading Rates (lb/ac/year)

STATSGO %	*14%*	*50%*	*18%*	*18%*		
	A	*B*	*C*	*D*	*Total Rate*	*CAST Target*
Forest	0.020	0.107	0.051	0.064	0.243	0.072
Mixed Open	0.023	0.121	0.049	0.058	0.250	0.356
Managed Turf	0.025	0.122	0.048	0.055	0.251	1.443

- The ‘CAST Target’ is the total weighted loading rate that was computed for each land cover in a previous step
- Each HSG entry in this table is created by the product of the STATSGO % for the column and the values in the Adjusted Loading Rates table on the previous slide
- Perform a goal seek in Excel to set the value of ‘Total Rate’ to the ‘CAST’ Target by changing the associated ‘Sum Adj. Rate’ cell from the table on the previous slide

Resulting Loading Rate Tables from Analysis

Computed VRRM 4.0 Values

2021 Adjusted Loading Rates (lb/ac/year) - Phosphorus

Category	*A*	*B*	*C*	*D*
Forest	0.042	0.064	0.085	0.106
Mixed Open	0.239	0.341	0.385	0.454
Managed Turf	1.053	1.403	1.544	1.754
Impervious	0.797	0.797	0.797	0.797

2021 Adjusted Loading Rates (lb/ac/year) - Nitrogen

Category	*A*	*B*	*C*	*D*
Forest	0.737	1.105	1.474	1.842
Mixed Open	1.090	1.558	1.759	2.074
Managed Turf	5.406	7.208	7.928	9.010
Impervious	10.990	10.990	10.990	10.990

Existing VRRM 3.0 Values

Current VRRM Loading Rates (lb/ac/year)

Category	*A*	*B*	*C*	*D*
Forest	0.046	0.068	0.091	0.114
Managed Turf	0.342	0.456	0.502	0.570
Impervious	2.167	2.167	2.167	2.167

Current VRRM Nitrogen Loading Rates (lb/ac/year)

Category	*A*	*B*	*C*	*D*
Forest	0.326	0.489	0.652	0.815
Managed Turf	2.445	3.259	3.585	4.074
Impervious	15.483	15.483	15.483	15.483

Initial loading rate computations yielded interesting results for the managed turf and impervious categories:

1) Impervious rates are around 37% of the VRRM 3.0 rates
2) Managed turf rates are approximately 3x the VRRM 3.0 rates

Resulting Loading Rate Tables from Analysis (cont.)

Why are the turf and impervious loading rates so different?

1) VRRM 3.0 is based on an average event mean concentration (EMC) of 0.26 mg/L across ALL land cover types. The loading adjustment between land covers and HSGs is made solely by RV coefficient adjustment.
2) The Chesapeake Bay Watershed Model (CAST loading rates) uses multiple engines to track the inputs/simulated transport/output of nutrients. This includes atmospheric deposition, soil nutrient migration, fertilizer applications, etc. Different land cover types use the applicable components of the model for tracking.
3) Scientific studies, including one recently completed in Fredericksburg by VT conclude that highly impervious areas do tend to have lower EMCs than residential (high turf/tree cover) areas.

Resulting Loading Rate Tables from Analysis (cont.)

- Despite EMC trends indicating that turf loadings could be higher than impervious, the magnitude of the turf rate increases warranted a closer look at the CAST turf inputs.

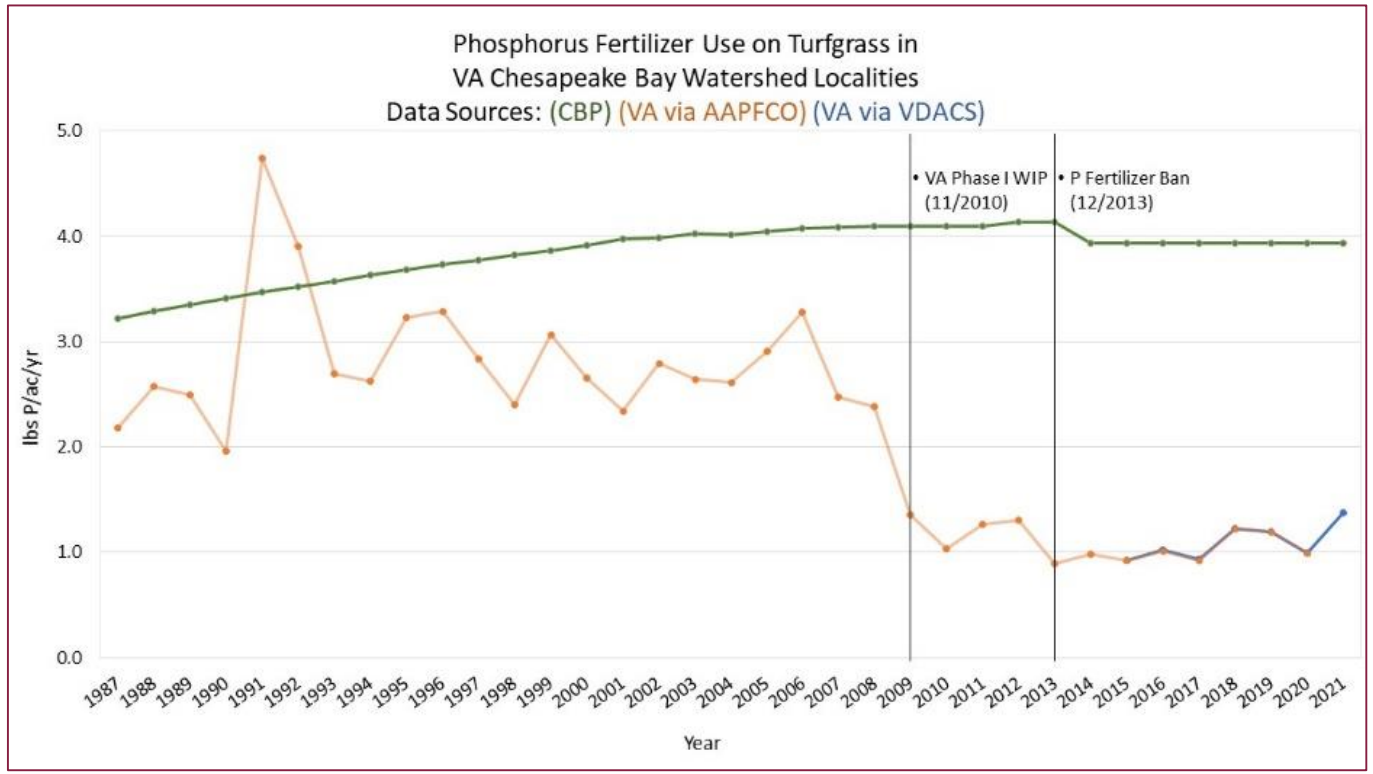
- On initial inspection of the fertilizer application rates for various jurisdictions, the VA phosphorus fertilizer application rate seemed surprising since Virginia enacted a phosphorus ban for residential applications (after establishment year) in 2013

- Based on some initial fertilizer data provided by EPA of raw fertilizer inputs, a closer look at this fertilizer input was initiated, since the 3.93 value appeared to be high.

Turf Application Rate (lbs/acre/yr)
VA: 3.93
DC: 3.66
MD: 2.81
DE: 2.19
PA: 1.22
NY: 0.82
WV: 0.40

Phosphorus Fertilizer Application Rate Analysis

- DEQ obtained fertilizer sales data through 2021 from Virginia Department of Agriculture and Consumer Services (VDACS) and Association of American Plant Food Control Officials (AAPFCO)
- DEQ/VT analyzed the data to determine deviation between historic CAST model input values and fertilizer sales figures



Phosphorus Fertilizer Application Rate Analysis (cont.)

- DEQ/VT computed an average phosphorus fertilizer sales rate of 1.06 lbs/acre/year since the ban for Chesapeake Bay communities. This is assumed to be similar to the eventual application rate.
- A custom run of the CAST model using 1.06 lbs/acre/year instead of 3.93 lbs/acre/year was requested and created.*

Category	CAST 2021 Rate lbs/ac/year	CAST Revised Rate lbs/acre/year
Forest	0.072	0.071
Mixed Open	0.356	0.355
Managed Turf	1.443	0.657
Impervious	0.797	0.794

*Note: This custom run is not possible through the online CAST scenario tool. This was created directly by Devereaux Consulting, LLC who manages the CAST model.

Revised Loading Rate Tables using Revised Target Loadings

Proposed VRRM 4.0 Values

2021 Adjusted Loading Rates (lb/ac/year) - Phosphorus

Category	*A*	*B*	*C*	*D*
Forest	0.042	0.062	0.083	0.104
Mixed Open	0.239	0.341	0.385	0.454
Managed Turf	0.479	0.639	0.703	0.799
Impervious	0.794	0.794	0.794	0.794

2021 Adjusted Loading Rates (lb/ac/year) - Nitrogen

Category	*A*	*B*	*C*	*D*
Forest	0.702	1.054	1.405	1.756
Mixed Open	1.091	1.559	1.760	2.075
Managed Turf	5.215	6.953	7.649	8.692
Impervious	11.797	11.797	11.797	11.797

Existing VRRM 3.0 Values

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Revised loading rate computations:

1) Impervious rates are still around 37% of the VRRM 3.0 rates
2) Managed turf rates are approximately 1.4x the VRRM 3.0 rates (vs. 3.0x)

05

Establish Nutrient Target Rates

Update the current VRRM Nutrient Target Rates

Current Rate

- 0.41 lbs/acre/year – based on a compromise of various methods

General Calculation Methodology for Update:

- Analyze the conversion of current non-developed lands to developed lands based on comparison of 2021 CAST model run and 2025 (Watershed Implementation target year) CAST model run
- Use USGS land cover conversion data for Virginia to establish % of forest/ag conversion
- Determine weighted loading rate of lands being converted
- Established rate is the maximum theoretical rate that must be maintained to result in no additional loading to the Chesapeake Bay (cause no harm)
- Excludes CAST loads from stream and shoreline categories since the ultimate load source in many cases is undefined and streams/shorelines aren't being developed.

Nutrient Target Computation Procedure

1) Calculate summary metrics for CAST 2025 and 2021 model runs. Note that both runs were completed using the 2021 BMP data set. Compute the 2021/2025 average TP loads for each category for the Edge of Stream (EOS) output from CAST. Land Cover Conversion data for Virginia from: https://www.sciencebase.gov/catalog/item/63334dc5d34e900e86c6227b

Values Used for Analysis

Category	2025 Area (acres)	2021 Area (acres)	Difference	% of Total Deviation in CAST	Updated Land Cover Conversion Used
Natural/Forest	9,424,007.68	9,446,636.97	22,629.28	49%	81%
Agriculture	2,317,967.62	2,341,688.33	23,720.71	51%	19%
Developed	1,967,149.61	1,920,799.62	46,349.99		

Nutrient Target Computation Procedure (cont.)

2) Calculate aggregate loading rates for Natural/Forest and Agriculture category from CAST data from the 2021 dataset.

Category	2021 P-Load (lbs)	2021 Area (acres)	Average Category Loading Rate (lb/ac/yr)
Natural/Forest	864,805.61	9,446,636.97	0.092
Agriculture	2,335,314.65	2,341,688.33	0.997
Developed	2,400,074.29	1,920,799.62	1.250

Nutrient Target Computation Procedure (cont.)

3) Adjust the average loading rates for the categories from the previous slide by the % of the overall difference for each category (from step 1).

Category	% of Total	Combined Loading Rate (lb/ac/yr)	Adjusted Loading Rate (lb/ac/yr)
Natural - excluding stream/shoreline	81%	0.092	0.074
Agriculture	19%	0.997	0.189
		Nutrient Target	0.264

Nutrient Target Computation Procedure (cont.)

4) A similar process can be used to compute a Total Nitrogen target. The final computation table from that process is shown below:

Category	% of Total	Combined Loading Rate (lb/ac/yr)	Adjusted Loading Rate (lb/ac/yr)
Natural - excluding stream/shoreline	81%	1.358	1.100
Agriculture	19%	12.536	2.382
		Nutrient Target	3.482

Nutrient Target Computation Procedure (cont.)

3) Alternative method used during development of previous target (0.41) based on the expected land cover of lands projected to be developed.

Three scenarios were considered:

a) 5% impervious, 30% turf, 65% forest
b) 7.5% impervious, 30% turf, 62.5% forest
c) 10% impervious, 30% turf, 60% forest

Category	CAST Revised Rate lbs/acre/year
Forest	0.071
Mixed Open	0.355
Managed Turf	0.657
Impervious	0.794

CAST loading rates (presented earlier) for impervious, turf, and forest are used for these computations

Nutrient Target Computation Procedure (cont.)

Three scenarios:

a) (.05)(0.794) + (0.30)(0.657) + (0.65)(0.071) = 0.28 lbs/ac/yr
b) (.075)(0.794) + (0.30)(0.657) + (0.625)(0.071) = 0.30 lbs/ac/yr
c) (0.10)(0.794) + (0.30)(0.657) + (0.60)(0.071) = 0.32 lbs/ac/yr

Range of this method is **0.28 – 0.32 lbs/ac/yr**

Range of previously discussed method is **0.27 – 0.33 lbs/ac/yr**

Since ranges of the methods are similar, the recommendation is to proceed with the **0.26 lbs/ac/yr** value computed from the CAST loading rate data and recently published Chesapeake Bay land conversion dataset

06

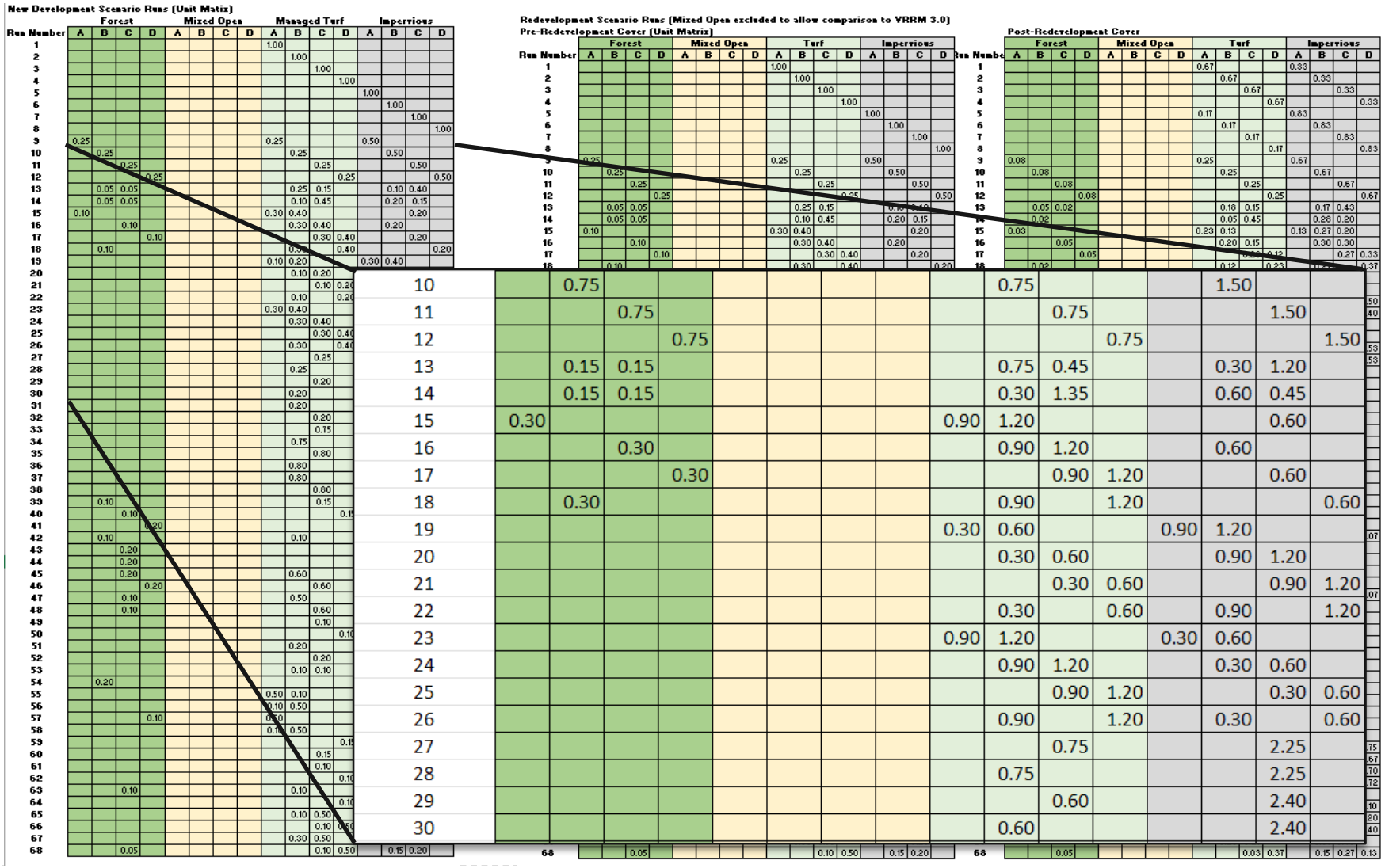
Comparisons of Results using VRRM 3.0 vs. 4.0 Spreadsheets

Comparing Results from VRRM 3.0 & VRRM 4.0

1. Matrices including 68 scenarios for both new and re-development applications were created that add up to a unit 1 acre. From here, a multiplication factor can be used to scale up to a disturbed area of any size.

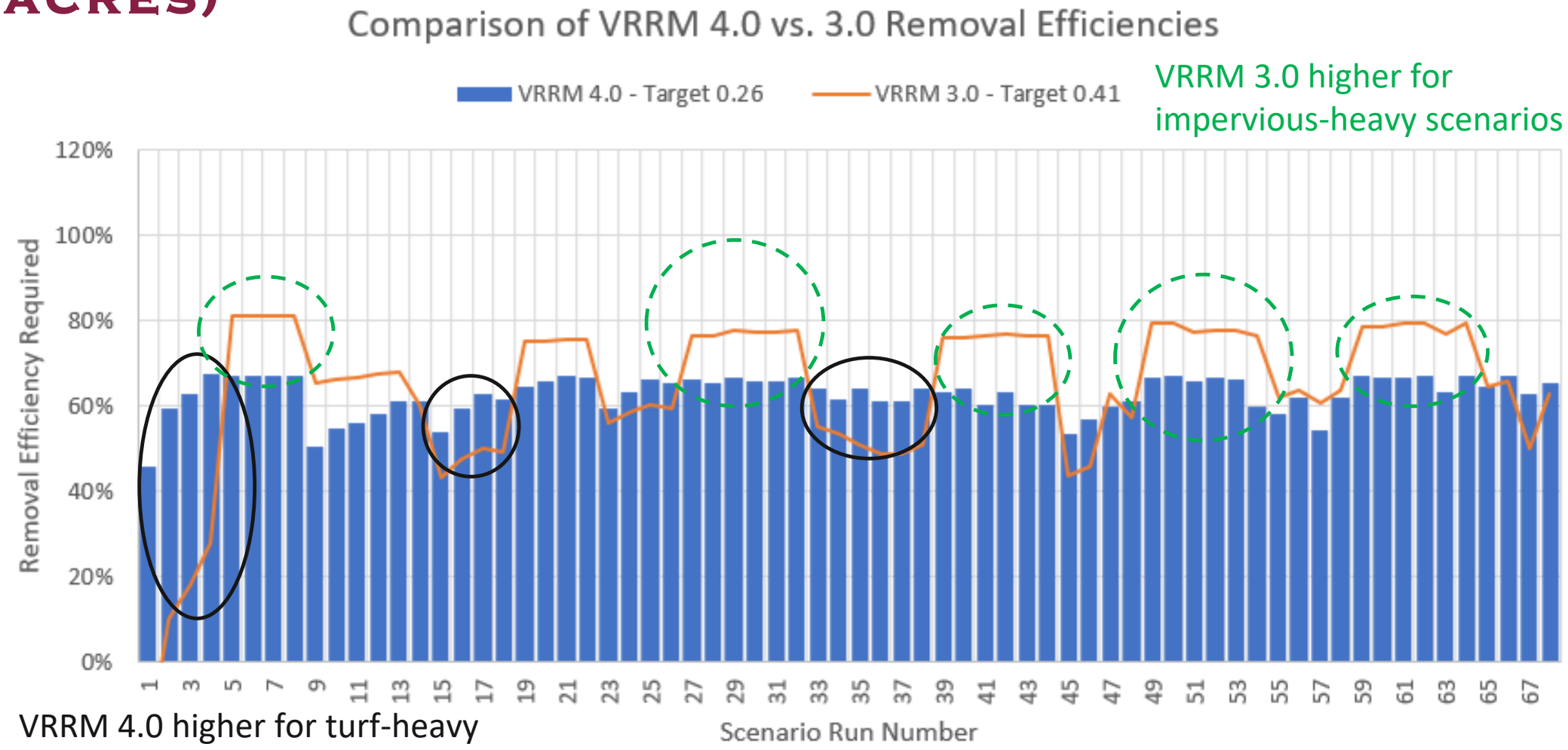
2. Comparisons were made based on the removal efficiency (TP removal divided by TP load) required. Direct comparison of the phosphorus load or phosphorus removal required is not prudent since BOTH the loading rates and nutrient target is modified in VRRM 4.0.

Scenario Matrices



- 68 Total Runs for both new and re-development
- Cross sampling of various managed turf and impervious development projects
- More limited number of forest-included scenarios

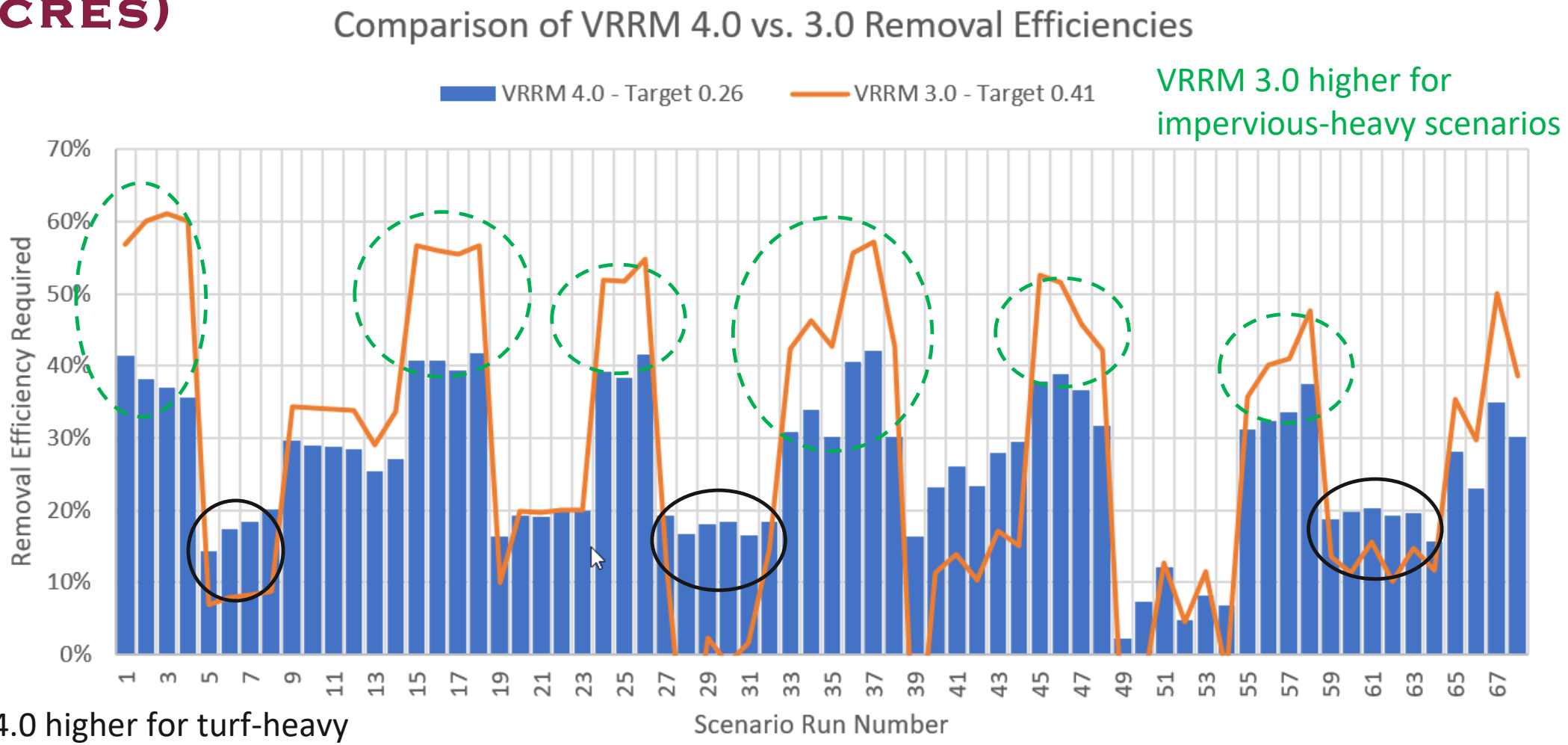
New Development Results (Total Disturbance 3 acres)



VRRM 3.0 higher for impervious-heavy scenarios

VRRM 4.0 higher for turf-heavy scenarios

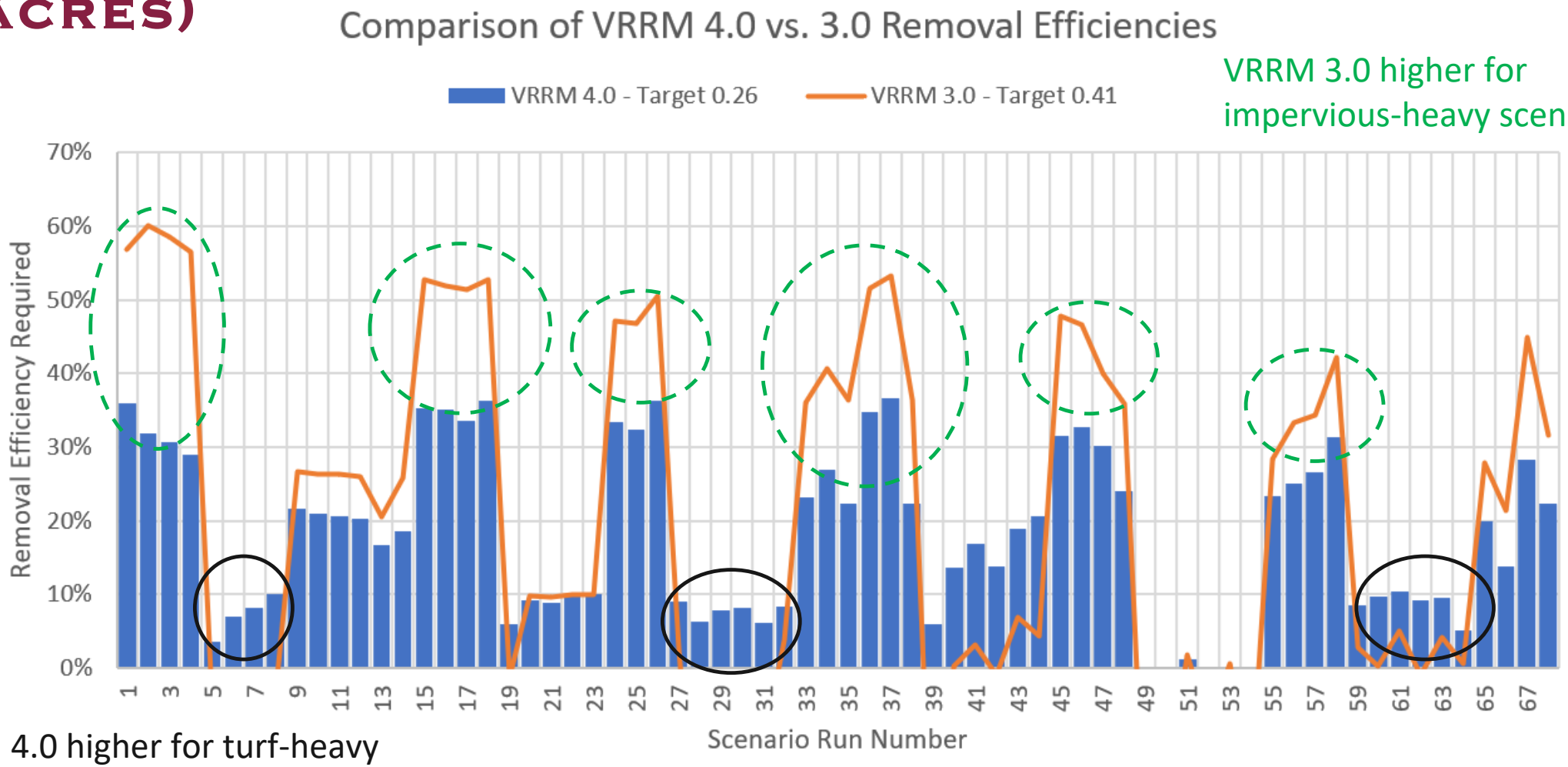
Re-development Results (Total Disturbance 3 acres)



VRRM 3.0 higher for impervious-heavy scenarios

VRRM 4.0 higher for turf-heavy scenarios

Re-development Results (Total Disturbance 0.8 acres)



VRRM 3.0 higher for impervious-heavy scenarios

VRRM 4.0 higher for turf-heavy scenarios

Comparing Results from VRRM 3.0 & VRRM 4.0 (cont.)

1. Compared the total efficiency required across all scenarios to determine trends in the two versions of the spreadsheets

<u>New Development [3 acres] (68 runs)</u>
VRRM 3.0: **70%** Efficiency Required (278.9 lb load, 195.2 lbs removal required*)
VRRM 4.0: **63%** Efficiency Required (144.1 lb load, 91.1 lbs removal required*)

<u>Re-development [3 acres] (68 runs)</u>
VRRM 3.0: **27%** Efficiency Required (308.0 lb load, 82.5 lbs removal required*)
VRRM 4.0: **26%** Efficiency Required (148.2 lb load, 38.9 lbs removal required*)

<u>Re-development [0.8 acres] (68 runs)</u>
VRRM 3.0: **18%** Efficiency Required (82.1 lb load, 15.2 lbs removal required*)
VRRM 4.0: **18%** Efficiency Required (39.5 lb load, 7.4 lbs removal required*)

*Note: Removal required does in some instances include negative values

07

VRRM Spreadsheet Revisions

Major Changes:

- Addition of the Mixed Open land use category (for specifying pre/post development acres; for specifying input to BMPs; for summary outputs)
  – impacts all tabs

- Addition of Regenerative Stormwater Conveyance and Tree(s) BMPs
  – drainage area tab

- Addition of ‘Composite Loading’ column that functions similarly to the existing ‘Composite Rv’ column
  – drainage area tab

- Consolidation of constants and coefficients into a single tab (streamline all spreadsheets)

Existing VRRM 3.0 New Development Site Tab

Project Name:
Date:
BMP Design Specifications List: 2013 Draft Stds & Specs

CLEAR ALL *(Ctrl+Shift+R)*

data input cells
constant values
calculation cells
final results

Site Information

ENTER AREAS IN DATA INPUT CELLS FOR RESULTS

Post-Development Project (Treatment Volume and Loads)

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be					0.00
Impervious Cover (acres)					0.00
					0.00

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Total Phosphorus (TP) EMC (mg/L)	0.26
Total Nitrogen (TN) EMC (mg/L)	1.86
Target TP Load (lb/acre/yr)	0.41
Pj (unitless correction factor)	0.90

Runoff Coefficients (Rv)

	A Soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary

Forest/Open Space Cover (acres)	0.00
Weighted Rv (forest)	0.00
% Forest	0%
Managed Turf Cover (acres)	0.00
Weighted Rv (turf)	0.00
% Managed Turf	0%
Impervious Cover (acres)	0.00
Rv (impervious)	0.95
% Impervious	0%
Site Area (acres)	**0.00**
Site Rv	**0.00**

Treatment Volume and Nutrient Loads

Treatment Volume (acre-ft)	0.0000
Treatment Volume (cubic feet)	0
TP Load (lb/yr)	0.00
TN Load (lb/yr) (Informational Purposes	0.00

Draft VRRM 4.0 New Development Site Tab

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 4.0 - Draft - For Review

Project Name:
Date:
BMP Design Specifications List: 2024 Draft Stds & Specs - For Review

CLEAR ALL *(Ctrl+Shift+R)*

data input cells
constant values
calculation cells
final results

Site Information

ENTER AREAS IN DATA INPUT CELLS FOR RESULTS

Post-Development Project (Treatment Volume and Loads)

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed					0.00
Impervious Cover (acres)					0.00
					0.00

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary

Forest Cover (acres)	0.00
Weighted Rv (forest)	0.00
% Forest	0%
Mixed Open (acres)	0.00
Weighted Rv (mixed open)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	0.00
Weighted Rv (turf)	0.00
% Managed Turf	0%
Impervious Cover (acres)	0.00
Rv (impervious)	0.95
% Impervious	0%
Site Area (acres)	**0.00**
Site Rv	**0.00**

Treatment Volume and Nutrient Loads

Treatment Volume (acre-ft)	0.0000
Treatment Volume (cubic feet)	0
TP Load (lb/yr)	0.00
TN Load (lb/yr)	0.00

Existing VRRM 3.0 Redevelopment Site Tab

Project Name:
Date:
Linear Development Project? Yes

CLEAR ALL (Ctrl+Shift+R)

data input cells
constant values
calculation cells
final results

Site Information

ENTER AREAS IN DATA INPUT CELLS FOR RESULTS

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* →

Maximum reduction required:	--
The site's net increase in impervious cover (acres) is:	--
Post-Development TP Load Reduction for Site (lb/yr):	--

Check:
BMP Design Specifications List: 2013 Draft Stds & Specs
Linear project? Yes
Land cover areas entered correctly? ___
Total disturbed area entered? ___

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed forest/open space					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be					0.00
Impervious Cover (acres)					0.00
					0.00

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be					0.00
Impervious Cover (acres)					0.00
Area Check	OK.	OK.	OK.	OK.	0.00

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Total Phosphorus (TP) EMC (mg/L)	0.26
Total Nitrogen (TN) EMC (mg/L)	1.86
Target TP Load (lb/acre/yr)	0.41
Pj (unitless correction factor)	0.90

Runoff Coefficients (Rv)

	A Soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest/Open Space Cover (acres)	--	--
Weighted Rv(forest)	--	--
% Forest	--	--
Managed Turf Cover (acres)	--	--
Weighted Rv(turf)	--	--
% Managed Turf	--	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest/Open Space Cover (acres)	--
Weighted Rv(forest)	--
% Forest	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
% Managed Turf	--

Land Cover Summary-Post

Post-ReDevelopment	
Forest/Open Space Cover (acres)	--
Weighted Rv(forest)	--
% Forest	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
% Managed Turf	--

Land Cover Summary-Post

Post-Development New Impervious

Draft VRRM 4.0 Redevelopment Site Tab

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet -- Version 4.0 -- Draft -- For Review

Project Name:
Date:
Linear Development Project? No

CLEAR ALL (Ctrl+Shift+R)

data input cells
constant values
calculation cells
final results

Site Information

ENTER AREAS IN DATA INPUT CELLS FOR RESULTS

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* →

Maximum reduction required:	--
The site's net increase in impervious cover (acres) is:	--
Post-Development TP Load Reduction for Site (lb/yr):	--

Check:
BMP Design Specifications List: 2024 Draft Stds & Specs -- For Review
Linear project? No
Land cover areas entered correctly? ___
Total disturbed area entered? ___

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be					0.00
Impervious Cover (acres)					0.00
					0.00

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be					0.00
Impervious Cover (acres)					0.00
Area Check	OK.	OK.	OK.	OK.	0.00

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr) --

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr) --

Final Post-Development TN Load --

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	--	--
Weighted Rv(forest)	--	--
Weighted Loading Rate(forest)	--	--
% Forest	--	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post

Post ReDev. & New Impervious	
Forest Cover (acres)	--
Weighted Rv(forest)	--
Wgt. Ld. Rate(forest)	--
% Forest	--

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	--
Weighted Rv(forest)	--
Wgt. Ld. Rate(forest)	--
% Forest	--

Land Cover Summary-Post

Post-Development New Impervious

Existing VRRM 3.0 Redevelopment Site Tab

Weighted Rv(forest)	--	--
% Forest	--	--
Managed Turf Cover (acres)	--	--
Weighted Rv(turf)	--	--
% Managed Turf	--	--
Impervious Cover (acres)	--	--
Rv(impervious)	--	--
% Impervious	--	--
Total Site Area (acres)	--	--
Site Rv	--	--

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	--	--
Pre-ReDevelopment Treatment Volume (cubic feet)	--	--
Pre-ReDevelopment TP Load (lb/yr)	--	--
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	--	--
Baseline TP Load (lb/yr) (**0.41 lbs/acre/yr** applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		--

Weighted Rv(forest)	--	
% Forest	--	
Managed Turf Cover (acres)	--	
Weighted Rv (turf)	--	
% Managed Turf	--	
Impervious Cover (acres)	--	
Rv(impervious)	--	
% Impervious	--	
Final Site Area (acres)	--	
Final Post Dev Site Rv	--	

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	--	
Final Post-Development Treatment Volume (cubic feet)	--	
Final Post-Development TP Load (lb/yr)	--	
Final Post-Development TP Load per acre (**lb/acre/yr**)	--	

ENTER ALL AREA INPUTS ABOVE FOR RESULTS

Weighted Rv(forest)	--	
% Forest	--	
Managed Turf Cover (acres)	--	
Weighted Rv (turf)	--	
% Managed Turf	--	
ReDev. Impervious Cover (acres)	--	
Rv(impervious)	--	
% Impervious	--	
Total ReDev. Site Area (acres)	--	
ReDev Site Rv	--	

Treatment Volume and Nutrient Load

Post-ReDevelopment Treatment Volume (acre-ft)	--	
Post-ReDevelopment Treatment Volume (cubic feet)	--	
Post-ReDevelopment TP Load (TP) (lb/yr)*	--	
Post-ReDevelopment TP Load per acre (**lb/acre/yr**)	--	
Max. Reduction Required (Below Pre-ReDevelopment Load)	--	

TP Load Reduction Required for Redeveloped Area (lb/yr)	--	

New Impervious Cover (acres)	0.00	
Rv(impervious)	--	

Post-Development Treatment Volume (acre-ft)	--	
Post-Development Treatment Volume (cubic feet)	--	
Post-Development TP Load (lb/yr)	--	

TP Load Reduction Required for New Impervious Area (lb/yr)	--	

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requirement for new impervious cover (based on new development load limit, 0.41lbs/acre/year).

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--
Linear Project TP Load Reduction Required (lb/yr):	--

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	--

Final Post-Development TN Load (Post-ReDevelopment & New Impervious) (lb/yr)	--

Draft VRRM 4.0 Redevelopment Site Tab

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	**Listed**	**Adjusted[1]**
Forest Cover (acres)	--	--
Weighted Rv(forest)	--	--
Weighted Loading Rate(forest)	--	--
% Forest	--	--
Mixed Open Cover (acres)	--	--
Weighted Rv(mixed)	--	--
Weighted Loading Rate(mixed)	--	--
% Mixed Open	--	--
Managed Turf Cover (acres)	--	--
Weighted Rv(turf)	--	--
Weighted Loading Rate(turf)	--	--
% Managed Turf	--	--
Impervious Cover (acres)	--	--
Rv(impervious)	--	--
Weighted Loading Rate(impervious)	--	--
% Impervious	--	--
Total Site Area (acres)	--	--
Site Rv	--	--

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	--	--
Pre-ReDevelopment Treatment Volume (cubic feet)	--	--
Pre-ReDevelopment TP Load (lb/yr)	---	---
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	--	--
Baseline TP Load (lb/yr) (**0.27 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover**)		--

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requirement for new impervious cover (based on new development load limit, 0.27 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post

Post ReDev. & New Impervious	
Forest Cover (acres)	--
Weighted Rv(forest)	--
Wgt. Ld. Rate(forest)	--
% Forest	--
Mixed Open Cover (acres)	--
Weighted Rv(mixed)	--
Wgt. Ld. Rate(mixed)	--
% Mixed Open	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
Wgt. Ld. Rate(turf)	--
% Managed Turf	--
Impervious Cover (acres)	--
Rv(impervious)	--
Wgt. Ld. Rate(impervious)	--
% Impervious	--
Final Site Area (acres)	--
Final Post Dev Site Rv	--

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume	--
Final Post-Development Treatment Volume (cubic	--
Final Post-Development TP Load (lb/yr)	---
Final Post-Development TP Load per acre (lb/acre/yr)	--

ENTER ALL AREA INPUTS ABOVE FOR RESULTS

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	--
Weighted Rv(forest)	--
Wgt. Ld. Rate(forest)	--
% Forest	--
Mixed Open Cover (acres)	--
Weighted Rv(mixed)	--
Wgt. Ld. Rate(mixed)	--
% Mixed Open	--
Managed Turf Cover (acres)	--
Weighted Rv (turf)	--
Wgt. Ld. Rate(turf)	--
% Managed Turf	--
ReDev. Impervious Cover (acres)	--
Rv(impervious)	--
Wgt. Ld. Rate(impervious)	--
% Impervious	--
Total ReDev. Site Area (acres)	--
ReDev Site Rv	--

Treatment Volume and Nutrient Load

Post-ReDevelopment Treatment Volume	--
Post-ReDevelopment Treatment Volume	--
Post-ReDevelopment Load (TP) (lb/yr)*	--
Post-ReDevelopment TP Load per acre (lb/acre/yr)	--
Max. Reduction Required (Below Pre-ReDevelopment Load)	--

TP Load Reduction Required for Redeveloped Area (lb/yr)	---	

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--

Treatment Volume and Nutrient Load

Post-Development Treatment Volume	--
Post-Development Treatment Volume (cubic	--
Post-Development TP Load (lb/yr)	--

TP Load Reduction Required for New Impervious Area (lb/yr)	---	

Draft VRRM 4.0 Drainage Area Tab(s)

Drainage Area A — VRRM 4.0, 2024 Draft - For Review

Drainage Area A Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv	Composite Loading P
Forest (acres)					0.00	0.00	0.00
Mixed Open (acres)					0.00	0.00	0.00
Managed Turf (acres)					0.00	0.00	0.00
Impervious Cover (acres)					0.00	0.00	0.00
				Total	0.00		

CLEAR BMP AREAS

otal Phosphorus Available for Removal in D.A. A (l 0.00

ost Development Treatment Volume in D.A. A (ft³) 0

Stormwater Best Management Practices (BR – Runoff Reduction) — Select from dropdown list:

Practice	Runoff Reduction Credit (%)	Mixed Open Credit Area (acres)	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	Volume from Upstream Practice (ft³)	Runoff Reduction (ft³)	Remaining Runoff Volume (ft³)	Total BMP Treatment Volume (ft³)	Phosphorus Removal Efficiency (%)	Phosphorus Load from Upstream Practices	Untreated Phosphorus Load to Practice (lb)	Phosphorus Removed By Practice (lb)	Remaining Phosphorus Load (lb)	Downstream Practice to be Employed
1. Vegetated Roof (RR)														
1.a. Vegetated Roof #1 (P-FIL-02)	45					0	0	0	0		0.00	0.00	0.00	
1.b. Vegetated Roof #2 (P-FIL-02)	60					0	0	0	0		0.00	0.00	0.00	
2. Rooftop Disconnection (RR)														
2.a. Simple Disconnection to A/B Soils (P-FIL-01)	50				0	0	0	0	0	0.00	0.00	0.00	0.00	
2.b. Simple Disconnection to C/D Soils (P-FIL-01)	25				0	0	0	0	0	0.00	0.00	0.00	0.00	
2.c. To Soil Amended Filter Path as per specifications (existing C/D soils) (P-FIL-	50				0	0	0	0	0	0.00	0.00	0.00	0.00	
2.d. To Dry Well or French Drain #1, Micro-Infiltration #1 (P-FIL-04)	50				0	0	0	0	25	0.00	0.00	0.00	0.00	
2.e. To Dry Well or French Drain #2, Micro-Infiltration #2 (P-FIL-04)	90				0	0	0	0	25	0.00	0.00	0.00	0.00	
2.f. To Rain Garden #1, Micro-Bioretention #1 (P-FIL-05)	40				0	0	0	0	25	0.00	0.00	0.00	0.00	
2.g. To Rain Garden #2, Micro-Bioretention #2 (P-FIL-05)	80				0	0	0	0	50	0.00	0.00	0.00	0.00	
2.h. To Rainwater Harvesting (P-BAS-04)	0				0	0	0	0	0	0.00	0.00	0.00	0.00	
2.i. To Stormwater Planter, Urban Bioretention (P-FIL-05)	40				0	0	0	0	25	0.00	0.00	0.00	0.00	
3. Permeable Pavement (RR)														
3.a. Permeable Pavement #1 (P-FIL-03)	45				0	0	0	0	25	0.00	0.00	0.00	0.00	
3.b. Permeable Pavement #2 (P-FIL-03)	75					0	0	0	25		0.00	0.00	0.00	
4. Grass Channel (RR)														
4.a. Grass Channel A/B Soils (P-CNV-01)	20				0	0	0	0	15	0.00	0.00	0.00	0.00	
4.b. Grass Channel C/D Soils (P-CNV-01)	10				0	0	0	0	15	0.00	0.00	0.00	0.00	
4.c. Grass Channel with Compost Amended Soils as per specs (P-FIL-08)	20				0	0	0	0	15	0.00	0.00	0.00	0.00	

Draft VRRM 4.0 Water Quality Compliance Tab

Site Results (Water Quality Compliance) VRRM 4.0, 2024 Draft - For Review

Area Checks	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	AREA CHECK
FOREST (ac)	0.00	0.00	0.00	0.00	0.00	OK.
MIXED OPEN (ac)	0.00	0.00	0.00	0.00	0.00	OK.
MIXED OPEN AREA TREATED(ac)	0.00	0.00	0.00	0.00	0.00	OK.
MANAGED TURF AREA (ac)	0.00	0.00	0.00	0.00	0.00	OK.
MANAGED TURF AREA TREATED (ac)	0.00	0.00	0.00	0.00	0.00	OK.
IMPERVIOUS COVER (ac)	0.00	0.00	0.00	0.00	0.00	OK.
IMPERVIOUS COVER TREATED (ac)	0.00	0.00	0.00	0.00	0.00	OK.
AREA CHECK	OK.	OK.	OK.	OK.	OK.	

Site Treatment Volume (ft^3)	--

Runoff Reduction Volume and TP By Drainage Area

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	TOTAL
RUNOFF REDUCTION VOLUME ACHIEVED (ft^3)	0	0	0	0	0	0
TP LOAD AVAILABLE FOR REMOVAL (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TP LOAD REDUCTION ACHIEVED (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TP LOAD REMAINING (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
NITROGEN LOAD REDUCTION ACHIEVED (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Total Phosphorus

FINAL POST-DEVELOPMENT TP LOAD (lb/yr)	--
TP LOAD REDUCTION REQUIRED (lb/yr)	--
TP LOAD REDUCTION ACHIEVED (lb/yr)	--
TP LOAD REMAINING (lb/yr):	--
REMAINING TP LOAD REDUCTION REQUIRED (lb/yr):	--

Total Nitrogen (For Information Purposes)

POST-DEVELOPMENT LOAD (lb/yr)	--
NITROGEN LOAD REDUCTION ACHIEVED (lb/yr)	--
REMAINING POST-DEVELOPMENT NITROGEN LOAD (lb/yr)	--

Draft VRRM 4.0 Runoff Volume and CN Tab

Runoff Volume and Curve Number Calculations, VRRM 4.0, 2024 Draft - For Review

Enter design storm rainfall depths (in):

1-year storm	2-year storm	10-year storm
0.00	0.00	0.00

Use NOAA Atlas 14 (http://hdsc.nws.noaa.gov/hdsc/pfds/)

***Notes (see below):**

[1] The curve numbers and runoff volumes computed in this spreadsheet for each drainage area are limited in their applicability for determining and demonstrating compliance with water quantity requirements. See VRRM User's Guide and Documentation for additional information.

[2] Runoff Volume (RV) for pre- and post-development drainage areas must be in volumetric units (e.g., acre-feet or cubic feet) when using the Energy Balance Equation. Runoff measured in watershed-inches and shown in the spreadsheet as RV(watershed-inch) can only be used in the Energy Balance Equation when the pre- and post-development drainage areas are equal. Otherwise RV(watershed-inch) must be multiplied by the drainage area.

[3] Adjusted CNs are based on runoff reduction volumes as calculated in D.A. tabs. An alternative CN adjustment calculation for Vegetated Roofs is included in BMP specification No. 5.

Drainage Area Curve Numbers and Runoff Depths*

Drainage Area A		A Soils	B Soils	C Soils	D Soils
Forest – undisturbed, protected forest or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Mixed Open – undisturbed/infrequently maintained grass or shrub land	Area (acres)	0.00	0.00	0.00	0.00
	CN	34	59	72	79
Managed Turf – disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	0.00	0.00
	CN	39	61	74	80
Impervious Cover	Area (acres)	0.00	0.00	0.00	0.00
	CN	98	98	98	98

Total Area (acres):	0.00
Runoff Reduction Volume (ft^3):	0

	$CN_{(D.A. A)}$
	0

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ *(watershed-inch)* with no Runoff Reduction*	0.00	0.00	0.00
$RV_{Developed}$ *(watershed-inch)* with Runoff Reduction*	0.00	0.00	0.00
Adjusted CN*	0	0	0

**See Notes above*

Drainage Area B		A Soils	B Soils	C Soils	D Soils
Forest – undisturbed, protected forest or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Mixed Open – undisturbed/infrequently maintained grass or shrub land	Area (acres)	0.00	0.00	0.00	0.00
	CN	34	59	72	79
Managed Turf – disturbed, graded for yards or other turf to	Area (acres)	0.00	0.00	0.00	0.00

Total Area (acres):	0.00
Runoff Reduction Volume (ft^3):	0

Draft VRRM 4.0 Constants Tab

VRRM 4.0, 2024 Draft - For Review

Constants

Target Rainfall Event (inches)	1.00
Target TP Load (lb/acre/yr)	0.26

Runoff Coefficients (Rv)

	A Soils	B Soils	C Soils	D Soils
Forest	0.02	0.03	0.04	0.05
Mixed Open	0.08	0.11	0.13	0.15
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Curve Numbers (CN)

	A Soils	B Soils	C Soils	D Soils
Forest	30	55	70	77
Mixed Open	34	59	72	79
Managed Turf	39	61	74	80
Impervious	98	98	98	98

Phosphorus Loading Rates (lb/acre/yr)

	A Soils	B Soils	C Soils	D Soils
Forest	0.042	0.062	0.083	0.104
Mixed Open	0.239	0.341	0.385	0.454
Managed Turf	0.479	0.639	0.703	0.799
Impervious Cover	0.794	0.794	0.794	0.794

NitrogenLoading Rates (lb/acre/yr)

	A Soils	B Soils	C Soils	D Soils
Forest	0.702	1.054	1.405	1.756
Mixed Open	1.091	1.559	1.760	2.075
Managed Turf	5.215	6.953	7.649	8.692
Impervious Cover	11.797	11.797	11.797	11.797

Practice	Runoff Reduction Credit (%)	Phosphorus Removal Efficiency (%)	Nitrogen Removal Efficiency (%)
1. Vegetated Roof (RR)			
1.a. Vegetated Roof #1 (Spec #5)	45	0	0
1.b. Vegetated Roof #2 (Spec #5)	60	0	0
2. Rooftop Disconnection (RR)			
2.a. Simple Disconnection to A/B Soils (Spec #1)	50	0	0
2.b. Simple Disconnection to C/D Soils (Spec #1)	25	0	0
2.c. To Soil Amended Filter Path as per			

Questions?